

What is claimed is:

1. A brake fluid pressure control device for a vehicle comprising:

a master cylinder for generating a first brake fluid pressure according to a brake pedal operation;

a wheel cylinder to which a second brake fluid pressure is applied for brake control;

a hydraulic booster for producing the second brake fluid pressure that is higher than the first brake fluid pressure;

a main pipeline connecting the master cylinder to the wheel cylinder via the hydraulic booster; and

a fluid pressure regulating unit disposed in the main pipeline between the master cylinder and the hydraulic booster, the fluid pressure regulating unit holding a pressure difference between a master cylinder side and a hydraulic booster side to a rated value;

wherein the hydraulic booster has a pump unit having intake and discharge ports, a flow amount amplifying unit, first and second pipelines to communicate with the main pipeline between the fluid pressure regulating unit and the wheel cylinder, respectively, and a flow amount amplification changing unit,

the pump unit operative, always when the brake pedal is stepped on, to suck via the intake port brake fluid from the main pipeline between the master cylinder and the fluid pressure regulating unit and to compress and discharge via the discharge port the brake fluid to the second pipeline,

the flow amount amplifying unit to which the brake fluid

discharged from the pump unit is supplied from the second pipeline and from which the brake fluid whose amount is larger than that supplied thereto is discharged to the first pipeline,

and the flow amount amplification changing unit operative to select one of the first and second pipelines as a pressurizing path through which the brake fluid is discharged to the main pipeline between the fluid pressure regulating unit and the wheel cylinder for producing the second brake fluid pressure.

2. A brake fluid pressure control device as in claim 1, wherein the flow amount amplification changing unit selects the first pipeline as the pressurizing path when a load of the pump unit is less than a predetermined value, and selects the second pipeline as the pressurizing path when a load of the pump unit is more than the predetermined value.

3. A brake fluid pressure control device as in claim 1, wherein the flow amount amplification changing unit selects the one of the first and second pipelines as the pressurizing path based on a value of the second brake fluid pressure.

4. A brake fluid pressure control device as in claim 1, wherein the flow amount amplification changing unit selects the one of the first and second pipelines as the pressurizing path based on a pressure value of the brake fluid discharged from the pump unit.

5. A brake fluid pressure control device as in claim 1, wherein the flow amount amplification changing unit selects the one of the first and second pipelines as the pressurizing path based on an amount of the brake fluid discharged from the pump unit.

6. A brake fluid pressure control device as in claim 5, wherein the flow amount amplification changing unit has an orifice provided in the second pipeline between the discharge port of the pump unit and the branch point where the brake fluid discharged from the pump unit is supplied to the flow amount amplifying unit; and

a bypass valve provided in the second pipeline in parallel to the orifice, the bypass valve operative to close the second pipeline on the side of the main pipeline with respect to the branch point when pressure of the brake fluid discharged from the pump unit is higher by a predetermined value than the second brake fluid pressure.

7. A brake fluid pressure control device as in claim 1, wherein the flow amount amplification changing unit selects the one of the first and second pipelines as the pressurizing path based on a difference between the first and second brake fluid pressures.

8. A brake fluid pressure control device as in claim 1, wherein the flow amount amplification changing unit selects

the one of the first and second pipelines as the pressurizing path based on a difference between a pressure of the brake fluid discharged from the pump unit and the second brake fluid pressure.

9. A brake fluid pressure control device as in claim 1, wherein the pump unit has a pump and a motor for driving the pump, and the flow amount amplification changing unit selects the one of the first and second pipelines as the pressurizing path based on a rotation number of the motor.

10. A brake fluid pressure control device as in claim 1, wherein the pump unit has a pump and a motor for driving the pump, and the flow amount amplification changing unit selects the one of the first and second pipelines as the pressurizing path based on a current amount applied to the motor.

11. A brake fluid pressure control device as in claim 1, wherein the fluid pressure regulating unit holds the pressure difference to the rated value defined by a current amount applied thereto, and

the flow amount amplification changing unit selects the one of the first and second pipelines as the pressurizing path based on a current amount applied to the fluid pressure regulating unit.

12. A brake fluid pressure control device as in claim 1, wherein the fluid pressure regulating unit holds the pressure

difference to the rated value defined by a duty ratio of current applied thereto,

wherein the flow amount amplification changing unit selects the one of the first and second pipelines as the pressurizing path based on the duty ratio of current applied to the fluid pressure regulating unit.

13. A brake fluid pressure control device as in claim 1, wherein a demand difference between an urgency brake control and a normal brake control is determined according to vehicle conditions, and the flow amount amplification changing unit selects the one of the first and second pipelines as the pressurizing path based on the demand difference.

14. A brake fluid pressure control device as in claim 1, wherein the pressurizing flow amount amplifying unit comprises a first step piston whose one end on a brake fluid supply side is provided with a small pressure-receiving surface and whose the other end on a brake fluid discharge side is provided with a large pressure-receiving surface so that the amount of the brake fluid to be discharged is amplified by an area ratio of the large pressure-receiving surface to the small pressure-receiving surface, compared to that to be supplied.

15. A brake fluid pressure control device as in claim 1, wherein the pressurizing flow amount amplifying unit comprises a first step piston whose one end is provided with

a small diameter portion and whose the other end is provided with a large diameter portion, a first guide wall on which the small diameter portion slides a first chamber surrounded by the first guide wall and a back surface of the small diameter portion, a second guide wall on which the large diameter portion slides, and a second chamber surrounded by the second guide wall and a front surface of the large diameter portion,

wherein the brake fluid discharged from the pump unit is supplied to the first chamber, and the brake fluid amplified according to a stroke movement of the first step piston is discharged from second chamber to the first pipeline.

16. A brake fluid pressure control device as in claim 15, wherein the flow amount amplification changing unit has a structure that the second pipeline is connected to the first guide wall so that the flow amount amplification changing unit selects the second pipeline as the pressurizing path when the first step piston finishes the stroke movement.

17. A brake fluid pressure control device as in claim 15, wherein the flow amount amplification changing unit comprises a first control valve, provided in the first pipeline, for controlling the brake fluid flow of the first pipeline, and

a second control valve, provided in the second pipeline, for controlling the brake fluid flow of the second pipeline.

18. A brake fluid pressure control device as in claim 17, wherein the flow amount amplification changing unit has a third chamber surrounded by a back surface of the large diameter portion and the second guide wall,

and the third chamber is provided with one of atmospheric pressure air and atmospheric pressure brake fluid, and, further,

wherein the first and second control valves are normally open valves that open the first and second pipelines, respectively, when not energized, and close the first and second pipelines, respectively, when energized.

19. A brake fluid pressure control device as in claim 16, wherein a circumferential surface of the small diameter portion is provided with a seal member for sealing between the first and second chambers, and

wherein the second pipeline communicates with the first chamber through a clearance between the small diameter portion and the first guide wall on a side of the first chamber with respect to the seal member.

20. A brake fluid pressure control device as in claim 19, wherein the first pipeline connected to the second guide wall on which the large diameter portion slides, and a distance S1 between the back surface of the small diameter portion and a position of the first guide wall where the first pipeline is connected is substantially equal to, but not shorter than a distance S2 between the back surface of the small diameter

portion and a position of the guide wall where the first pipeline is connected, in a state that the pump unit does not discharge the brake fluid.

21. A brake fluid pressure control device as in claim 15, wherein the flow amount amplification changing unit comprises a first valve element formed at the small diameter portion on a side of the first chamber, a biasing member for urging the first valve element in an opposite direction in which the first step piston moves when the brake fluid is discharged from the pump unit, and a first valve seat formed in the first chamber at a position to which the second pipeline connected so that the biasing member urges the first valve element so as to seat on the first valve seat to close the second pipeline until the first step piston moves by a predetermined distance, and the first valve element leaves the first valve seat to open the second pipeline when the first step piston further moves beyond the predetermined distance.

22. A brake fluid pressure control device as in claim 21, wherein the flow amount amplification changing unit has a second valve element that moves in conjunction with the first step piston, and a second valve seat formed in the second chamber at a position to which the first pipeline is connected so that the first pipeline is closed when the second valve element is seated on the second valve seat, according to the movement of the first step piston, and, further, wherein a lift amount S3



of the first valve element is substantially equal to, but not shorter than a lift amount S4 of the second valve element.

23. A brake fluid pressure control device as in claim 15, wherein the pressurizing flow amount amplifying unit comprises a third chamber surrounded by a back surface of the large diameter portion and the second guide wall, and the third chamber is connected to the main pipeline between the fluid pressure regulating unit and the master cylinder.

24. A brake fluid pressure control device as in claim 23, wherein an effective diameter of the master cylinder is variable.

25. A brake fluid pressure control device as in claim 23, wherein the master cylinder comprises a large diameter input piston driven by the brake pedal, and primary and secondary pistons, whose each diameter is smaller than that of the input piston, driven by the input piston,

a reservoir that reserves brake fluid with atmospheric pressure,

a middle chamber formed by the input piston and the primary piston is communicated with the reservoir, and

a electrical valve is provided between the middle chamber and the reservoir for controlling communication and interruption therebetween.

26. A brake fluid pressure control device as in claim 25, wherein the electrical valve keeps the middle chamber at atmospheric pressure, when not energized.

27. A brake fluid pressure control device as in claim 15, wherein the flow amount amplification changing unit has a third chamber surrounded by a back surface of the large diameter portion and the second guide wall,

and the third chamber is provided with one of atmospheric pressure air and atmospheric pressure brake fluid.

28. A brake fluid pressure control device as in claim 15, wherein the pressurizing flow amount amplifying unit is provided with a third pipeline connecting the second chamber to the main pipeline between the master cylinder and fluid pressure regulating unit; and

a check valve provided in the third pipeline for allowing brake fluid to flow only from the main pipeline to the second chamber.

29. A brake fluid pressure control device as in claim 14, wherein the fluid pressure regulating unit regulates the pressure difference so that the pressure of the brake fluid discharged from the pump unit corresponds to the second brake fluid pressure amplified by the area ratio of the large pressure-receiving surface to the small receiving-surface.

30. A brake fluid pressure control device as in claim 14, wherein the pressurizing flow amount amplifying unit comprises a first step piston whose one end is provided with small diameter portion and whose the other end is provided with a large diameter portion, a first guide wall on which the small diameter portion slides a first chamber surrounded by the first guide wall and a back surface of the small diameter portion, a second guide wall on which the large diameter portion slides, and a second chamber surrounded by the second guide wall and a front surface of the large diameter portion, when an urgency brake control for increasing and decreasing the second brake fluid pressure is required during a time when the brake fluid is discharged to the first pipeline, the flow amount amplification changing unit selects the second pipeline as the pressurizing path so that the first chamber communicates with the second chamber so as to return the step piston to an original position.

31. A brake fluid pressure control device as in claim 17, wherein, when an urgency brake control for increasing and decreasing the second brake fluid pressure is required during a time when the brake fluid is discharged to the first pipeline, the first and second control valves are switched so that the second pipeline is selected as the pressurizing path.

32. A brake fluid pressure control unit as in claim 16, wherein the pressure flow amount amplifying device has a third

chambers surrounded by a back surface of the large diameter portion and the second guide wall and the flow amount amplification changing unit has a spool valve unit formed at the first guide wall so that the second pipeline is connected via the third chamber to the spool valve unit,

and, further, wherein the hydraulic booster is provided with a first check valve provided in the second pipeline for allowing brake fluid to flow only from the third chamber to the second pipeline,

a first feedback pipeline, connecting the second pipeline between the first check valve and the main pipeline on a side of the wheel cylinder to the discharge port of the pump unit;

a second check valve provided in the first feedback pipeline for allowing brake fluid to flow only from the main pipeline on the side of wheel cylinder to the discharge port of the pump unit;

a second feedback pipeline for connecting the third chamber to the main pipeline between the master cylinder and the fluid pressure regulating unit; and

a third check valve provided in the second feedback pipeline for allowing brake fluid to flow only from the main pipeline between the master cylinder and the fluid pressure regulating unit to the third chamber.

33. A brake fluid pressure control device as in claim 14, further comprising: a pedal detecting unit for detecting the pedal depressing state of the brake pedal;

wherein the fluid pressure regulating unit regulates the pressure difference so that the pressure of the brake fluid discharged how the pump unit corresponds to the second brake fluid pressure amplified by the area ratio of the large pressure-receiving surface to the small receiving-surface, when a detected result of the pedal condition detecting unit requires to promote a deceleration of the vehicle, and

wherein the fluid pressure regulating unit regulates the pressure difference so that the pressure of the brake fluid discharged from the pump unit correspond to the second brake fluid pressure, when the detected result of the pedal detecting unit requires to maintain or restrict the deceleration of the vehicle.

34. A brake fluid pressure control device as in claim 15, wherein the pressurizing flow amount amplifying unit is provided with the first step piston having a middle diameter portion between the small and large diameter portion, a third guide wall on which the middle diameter portion slide a third chamber surrounded by the second guide wall and a back surface of the large diameter portion and a fourth chamber surrounded by the third guide wall and a back surface of the middle diameter portion.

35. A brake fluid pressure control device as in claim 34, wherein the pressurizing flow amount amplifying unit has first and second spool valve units formed in the first and the

third guide walls on which the small and middle diameter portion slide, and

the first and second spool valve units communicate with the fourth and third chambers, respectively, and, further,

wherein the second pipeline communicates with the first chamber via the third chamber, the second spool valve unit, the forth chamber and the first spool valve unit.

36. A brake fluid pressure control device as in claim 35 wherein the hydraulic booster is provided with a first feedback pipeline connecting the respective third and fourth chambers to the discharge port of the pump unit, and

a one-way valve provided in the first feedback pipeline for allowing the brake fluid to flow only from the respective third and fourth chambers to the discharge port of the pump unit.

37. A brake fluid pressure control device as in claim 35, wherein the hydraulic booster is provided with a check valve provided in the second pipeline for allowing brake fluid to flow only from the third chamber to the second pipeline;

a second feedback pipeline connecting the second pipeline between the check valve and the main pipeline on a side of the wheel cylinder to the discharge port of the pump unit; and

a control valve provided in the second feedback pipeline for controlling communication and interruption of the second feedback pipeline.

38. A brake fluid pressure control device as in claim 14, wherein the hydraulic booster is provided with a pressurization unit having a second step piston having small and large diameter portions, first and second guide walls on which the small and large diameter portions slide, a first chamber surrounded by the first guide wall and a front surface of the small diameter portion and a second chamber surrounded by the second guide wall and a back surface of the large diameter portion, and the first chamber communicates with the first pipeline, and the second chamber communicates with the main pipeline between the master cylinder and the fluid pressure regulating unit, so that brake fluid in the first chamber is pressurized by the first brake fluid pressure applied to the second chamber to increase the second brake fluid pressure.

39. A brake fluid pressure control device as in claim 38, wherein the pressurization unit increase the second brake fluid pressure based on an area ratio of a pressure-receiving surface of the large diameter portion to that of the small diameter portion.

40. A brake fluid pressure control device as in claim 38, wherein the hydraulic booster is provided with a normally closed electrical valve provided in the second pipeline as the flow amount amplification changing unit, and the pressurization unit is provided with a third chamber surrounded by a front

surface of the large diameter portion and the second guide wall and the third diameter is provided with one of an atmospheric pressure air and an atmospheric pressure brake fluid.

41. A brake fluid pressure control device as in claim 15, wherein the flow amount amplifying unit has a third chamber surrounded a back surface of the larger diameter portion and the second guide wall, and the third chamber is provided with one of an atmospheric pressure and an atmospheric brake fluid, and further,

wherein during a cooperative control with a regenerative braking, the first step piston is controlled to return toward an initial position by the fluid pressure regulation unit if it is required to reduce pressure corresponding to a regenerative braking from the second brake fluid pressure to be defined when the regenerative braking is not executed, while the first step piston is pushed stronger if it is required to increase pressure corresponding to a regenerative braking from the second brake fluid pressure to be defined when the regenerative braking is not executed.

42. A brake fluid pressure control device as in claim 41, wherein the hydraulic booster is provided with a first linear valve provided in the second pipeline as the flow amount amplification changing unit for controlling a differential pressure between the discharge port of the pump and the main pipeline on a side of the wheel cylinder;



a third pipeline connecting the main pipeline on a side of the wheel cylinder to the intake port of the pump, and

a second linear valve provided in the third pipeline for controlling a differential pressure between the main pipeline on a side of the wheel cylinder and the intake port of the pump.

43. A brake fluid pressure control device as in claim 42, wherein a control for generating differential pressure by the first linear valve is synchronized with a control for driving the fluid pressure regulating unit when the pressure corresponding to a regenerative braking is reduced from the second brake fluid pressure, while a control for generating the differential pressure by the second linear valve is synchronized with a control for driving the fluid pressure regulating unit when the pressure corresponding to a regenerative braking is increased to the wheel cylinder pressure.

44. A brake fluid pressure control device as in claim 41 further comprising: a pedal shift absorbing unit provided between the main pipeline on a side of the master cylinder and the first pipeline;

wherein the pedal shift absorbing unit has a second step piston having small and large diameter portions, first and second guide walls on which the small and large diameter portions slide, a first chamber surrounded by the first guide wall and a front surface of the small diameter portion and a second chamber

surrounded by the second guide wall and a back surface of the large diameter portion, and the first chamber communicates with the first pipeline, and the second chamber communicates with the main pipeline between the master cylinder and the fluid pressure regulating unit, so that a shift of the brake pedal depending on a pressure fluctuation of the second brake fluid pressure is absorbed by the first brake fluid pressure applied to the second chamber.

45. A brake fluid pressure control device as in claim 44, wherein the second chamber of the pedal shift absorbing unit absorbs the brake fluid to be returned to the main pipeline on a side of the master cylinder by the pressure fluctuation of the second brake fluid pressure, based on a area ratio of a pressure-receiving surface of the large diameter portion to that of the small diameter portion.

46. A brake fluid pressure control device as in claim 44 further comprising: a normally closed electrical valve disposed in the first pipeline for closing the first pipeline when not energized and opening the first pipeline when energized, wherein the second step piston is operated when the electrical valve is energized, while the second step piston is not operated when the electrical valve is not energized.

47. A brake fluid pressure control device as in claim 1 further comprising: a master cylinder pressure detecting unit;

wherein the fluid pressure regulating unit regulates the differential pressure based on a detecting result of the master cylinder pressure detecting unit.

48. A brake fluid pressure control device as in claim 1 further comprising: a pedal condition detecting unit for detecting a pedal depressing state of the brake pedal; wherein the fluid pressure regulating unit regulates the differential pressure based on a detecting result of the pedal detecting unit.

49. A brake fluid pressure control device as in claim 48, wherein an amount of the brake fluid discharged from the pump unit is controlled by a change ratio of the detected result of the pedal condition detecting unit.

50. A brake fluid pressure control device as in claim 48, wherein, when there is a requirement to promote a deceleration of the vehicle as the detected result of the pedal detecting unit, an amount of brake fluid discharged from the pump unit is controlled to a maximum value and then is controlled to a smaller value according to a degree of the requirement to promote the deceleration, and, further,

wherein, when there is a requirement to maintain or decrease the deceleration as the detected result of the pedal detecting unit, the amount of the brake fluid discharged from the pump unit is controlled to a minimum value or zero.

51. A brake fluid pressure control device as in claim 1, wherein the fluid pressure regulating unit is provided between the master cylinder and the discharge port of the pump unit.

52. A brake fluid pressure control device as in claim 1, wherein fluid pressure regulating unit is provided between the master cylinder and the first pipeline.

53. A brake fluid pressure control device as in claim 1 further comprising: a pressure regulating reservoir provided between the master cylinder and the intake port of the pump unit for restricting brake fluid pressure provided to the pump unit.